Forest Health Protection

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North Fork Campground Hazard Tree Assessment,
Salmon River Ranger District, Nez Perce National Forest

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Summary

The North Fork Campground is located on Slate Creek and the mouth of the North Fork of Slate Creek, Salmon River Ranger District, Nez Perce National Forest. This is a small campground with four developed units, an outhouse and a trailhead. It is situated between Forest Road # 999 and Slate Creek.

Severe root disease had been noted by Forest personnel so the need to assess and remove hazardous trees was anticipated. We conducted a standard all-trees hazard assessment with stem mapping on April 28, 2010. In total we inspected and mapped 117 trees, identified 22 for immediate removal, and ten to be monitored annually. All trees to be removed were marked with numbered tags and flag with ribbon to assist with identification for removal.

A vegetation management plan should be developed for this site to provide more suitable replacement trees as disease-caused hazard tree removal have rendered some parts of the campground virtually tree-less.

This is the final report of our findings including a monitoring plan for trees in the campground with known defects. Supporting data appear in appendices.

Figure 1. North Fork Campground has a serious root disease problem that has resulted in standing mortality as well as tree failures. Stumps from dead-tree removals are common throughout the campground. Many more hazardous trees have been indentified for removal.

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Introduction

The campground is located in a mature stand of grand fir from which most of the Douglas-fir had already died out. A very minor component of young Engelmann spruce is present. Pacific yew is scattered throughout in small numbers, and a cluster of mature birch grows along the creek on the southeast side of the campground. Grand fir and Douglas-fir saplings are common, especially in the canopy openings from earlier tree removals and deaths.

We previously visited in November 2009 (CFO-TR-09-028) and recommended that it be closed until significant tree hazards were addressed. We recommended a hazard tree assessment be completed because of the extensive signs and symptoms of root disease and stem decay which could cause tree failure.

The objective of the tree hazard assessment was to identify immediate tree hazards and recommend removals or close monitoring, as needed. Tree removals were to be completed before reopening the campground.

A long term vegetation management plan is still needed to correct the current trend toward increasing removal rates and inappropriate species regeneration. The condition of the campground forest has deteriorated for many years and will continue to do so as long as grand fir and Douglas-fir are the main forest canopy.

The District has already completed NEPA work for removals and planned to remove tagged trees prior to opening the campground this spring. The recreation staff will also review campsite placement and may alter the layout of the campground to better utilize the openings created by hazard tree removal. They plan to re-vegetate areas opened by hazard tree removals, and will favor species which are more tolerant of root disease and less susceptible to decay.

Methods

For the most part, we used standard methods to assess hazard trees. Trees within striking distance of a recognized target were examined and mapped. The species and diameter were noted and observable damages or deformities were recorded by class and severity codes (FHP 2006). Trees were categorized as: 1) relatively safe, 2) sufficiently hazardous to warrant removal, or 3) having a developing condition that should be monitored.

This survey was conducted by Megan Moynihan, silviculturist and Josh Lattin, recreation technician, both from the Nez Perce National Forest, and Carol Randall and Susan Hagle, Forest Health Protection entomologist and pathologist, respectively.

Mapping trees

All trees within range of a target were noted on hand-drawn maps, with measured and approximated azimuths and distances from a reference point. The reference points (Figure 2) were mapped by measuring their azimuth and distance from a single location (the outhouse). Fire rings were the most common marker for the reference point, although the outhouse also served. These maps were entered into Arc Map for tracking and display.

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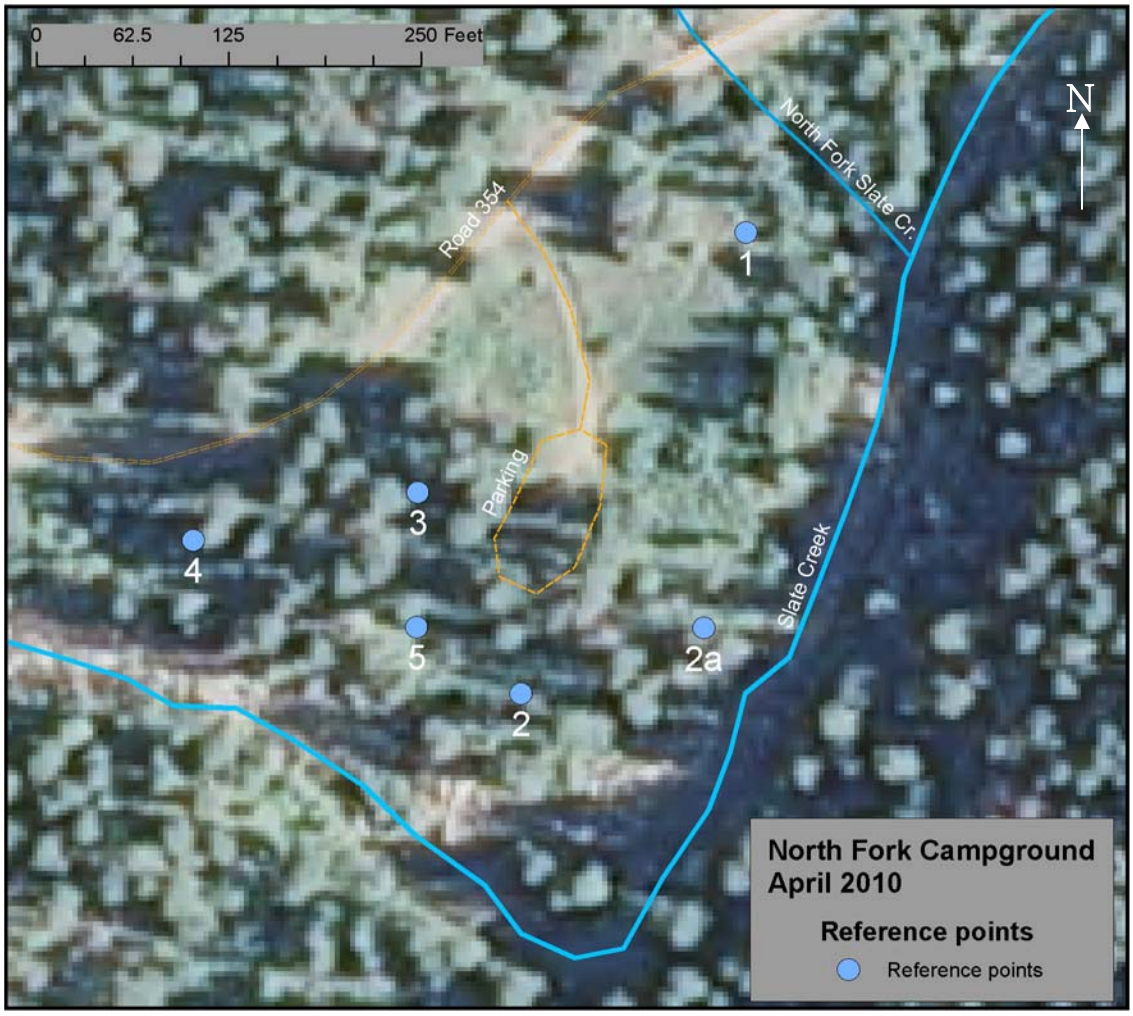

Figure 2. Reference points for the survey. All points are centered on a fire ring except #5 which is the southeast corner of the outhouse.

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Damages and Defects

For every tree inspected we recorded species, diameter at breast height (dbh), defect category, and defect severity (Appendix A). We examined each tree for six categories of defect:

D: Decay or Cavity- trees where significant decay is suspected (verified suspected decay by using an increment borer and recording the inches of sound wood at the thinnest point)

L: Lean/ Sweep- entire length of tree bole not perpendicular to ground

W: Stem Damage and Wounds- lightening, frost cracks, mechanical, animal, human damage

B: Branches, Forks, Witches Brooms, and Tops

C: Cankers- blister rust, gall rust, dwarf mistletoe, etc.

R: Root Damage, Root Disease

When a defect was noted, its severity was rated from low (1) to high (4). Trees killed by root disease were assigned a root disease severity of 4.

Decay, especially butt rot, was a common condition in the campground. When stem decay was suspected, an increment borer was used to determine the amount of sound wood remaining, the rind. If there was incipient decay, but no advanced decay, fruiting bodies, or minor cavities the tree was assigned a severity of 1 (1D), if advanced decay or large cavities observed, but the rind was greater than 60% of the radius, the tree was assigned a severity of 2 (2D), if the rind was 30%-60% of the radius (excluding the bark), the tree was assigned a severity code of 3 (3D), and if sound wood was less than 30% of the radius the tree was assigned a severity code of 4 (4D). Meg noted that if the rind of a large diameter tree was less than 6 inches, when the tree was felled it could shatter, creating additional cleanup work.

Target considerations

An important part of hazard tree assessment is judging the likelihood that a tree will fail in the direction of a target. For any tree, there are 360 degrees in which a tree could potentially fail. The farther the tree is from the target, the narrower the angle of failure that will allow the tree to strike a limited target such as a table or tent pad. The closer a failure-prone tree stands to the target, the broader the angle of failure that will strike the target. Therefore, failure-prone trees nearest critical targets, are most often identified for removal.

Leans are an important consideration for judging probably angle of failure. A strong lean away from a target is a good indication, but not a guarantee. Trees with neutral or toward-target leans present increased risk, especially when combined with root or stem decay.

Three types of targets are recognized based on the risk that a hazard tree failure may result in personal injury or property loss:

- 1 —Target receives occasional use: trails, signs, no vehicles (lowest risk)
- 2— Target intermittently used: picnic area, day use, busy trail
- 3— Target frequently used: camp sites, parking areas, permanent structures (highest risk)

The campground has four camp sites that were type 3 targets. The outhouse is to be relocated so it was not assessed as a target at this time. Access roads were considered type 1 targets because of the low traffic volume. Trees were inspected and mapped. Many of the trees with root disease leaned toward the creek and were not considered hazardous although they were likely to fall.

Removal recommendations

The procedure we used to assign a recommendation for tree removal was carefully considered on the basis of both probable tree failure and probable damage or injury. Because most tree have crown symptoms of root disease, the presence of apparent disease was not sufficient to cause tree removal. Had this been the case, there would have been virtually no large trees retained. The severity of crown symptoms and presence of other indicators, such as a toward-target lean, were used to develop a conservative decision for tree removal. When the

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recommended action for a tree was removal, a tree tag was nailed into the base facing the map reference point. The tree tag was to ensure that tree fallers will find all identified trees for removal, and that recreation staff can verify that all hazard trees have been removed prior to opening the campground.

Monitoring

Trees designated for monitoring have conditions that can be expected to worsen with time. In the case of the North Fork Campground, root disease and butt rot with or without leans or evidence of root movement are the main causes of defects resulting in the decision to monitor a tree. Monitoring results in a yearly expense and should produce a permanent record for each designated tree. It is important to follow through with prescribed monitoring of trees where significant defects have been identified. Anytime a tree with recognized defects is retained, the risk of failure is acknowledged and considered acceptable for the time being.

Annual monitoring is usually sufficient. A table documenting the location and condition of each identified tree is generated following the tree hazard assessment. A row should be added to the table for each tree to enter an update after each yearly examination. Alternatively, a data form can be printed for each tree that allows room for notes from each yearly evaluation to be entered. This permanent record will allow the examiner to determine whether significant changes have occurred and to better judge the rate of change. This background will help in making a decision to finally remove a tree that has become too risky.

Summary of Results **(Data are attached as Excel file; North Fork Hazard Tree.xlsx)**

Of the 116 trees mapped in the campground, 75% were grand fir and 11% were Douglas-fir (Table 1). The largest trees were grand fir, averaging 22.6 inches diameter at breast height (dbh). The largest grand fir was over 47 inches dbh and over half of the grand fir were at least 24 inches dbh. Only two of the Douglas-fir were more than 24 inches dbh and both were recommended for removal because of advanced root disease.

Overall 21 trees were recommended for immediate removal and one for optional removal (Table 2). Nineteen of the trees to be removed were grand fir and the rest were Douglas-fir. The average dbh of trees to be removed was 26.5, which would leave trees with an average dbh of 17.9 inches (Table 3).

The 18 grand fir trees recommended for removal averaged 27 inches dbh, those remaining will

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Table 1. Composition of North Fork Campground

Species	Avg dbh	# trees	% of trees
DF	15.5	13	11.21%
ES	18.9	3	2.59%
GF	22.6	87	75.00%
BP	10.5	4	3.45%
TB	7.9	9	7.76%
Total	**20.2**	**116**	**100.00%**

DF = Douglas-fir, ES = Engelmann spruce, GF = grand fir, BP = paper birch, TB = Pacific yew

Table 2. Number of trees by recommended action

Species	Tentative removal	monitor	remove	no action	all
DF		1	3	9	13
ES				3	3
GF	1	7	18	61	87
BP				4	4
TB				9	9
Total	**1**	**9**	**21**	**86**	**116**

DF = Douglas-fir, ES = Engelmann spruce, GF = grand fir, BP = paper birch, TB = Pacific yew

Table 3. Average dbh by action recommendation					
Species	tentative removal	monitor	remove	no action	all
DF		22.5	24.3	11.7	15.5
ES				18.9	18.9
GF	23.5	29.2	26.9	20.6	22.6
BP				10.5	10.5
TB				7.9	7.9
Total	**23.5**	**26.2**	**26.5**	**17.9**	**20.2**

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average 21 inches dbh. Root disease alone or in combination with stem decay and/or a significant lean toward a target were the most common reasons for recommending removal of grand fir. Three Douglas-fir trees recommended for removal were dead or nearly dead from root disease. They averaged about 24 inches dbh, while the average dbh of remaining Douglas-fir trees was 12 inches.

Of 116 standing trees, 45% had root disease, 22% had heart or butt rot, and 18% had significant leans toward a highly-rated target (Table 4). Of 36 trees with significant leans, 15 lean away from the potential target.

Given the species composition and age, these are expected conditions. Of the 87 live, standing trees that would remain after the recommended removals, eight have been identified for specific annual monitoring. Root disease, butt rot and leans were the most common conditions in these trees (Table 5). Most should be examined regularly for impending death from root disease, stem weakening from root disease-associated butt rot, and for evidence of increasing instability in leans.

The most severe wounds observed were cracks that were mostly a result of butt rot. A modest level of human-caused injury was observed in grand fir. Some bark removal was seen in pacific yew, probably from animal feeding or antler rubbing. Wounds were not an important factor for tree removal recommendations, nor as a predisposing condition for decay.

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Table 4. Damages in trees recommended for removal

Tree Species	Total trees	Average DBH	Root disease*	Heart or butt rot*	Lean toward target	Wound*	Unstable/ multiple top
Grand fir	18	26.9	15	11	9	9	4
Douglas-fir	3	24.3	3	0	1	0	2
All trees	21	26.5	18	11	10	9	6

*Rated severity 2 or higher

Table 5. Damages in trees recommended for monitoring

Tree Species	Total trees	Average DBH	Root disease*	Heart or butt rot*	Lean toward target	Wound*	Unstable/ multiple top
Grand fir	7	29.2	4	3	4	1	0
Douglas-fir	1	22.5	1	1	1	0	0
Pacific yew	1	8.7	0	0	0	1	0
All trees	9	26.2	5	4	5	2	0

*Rated severity 2 or higher

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In addition to butt rot from annosus root disease, two trees had stringy stem decay caused by Indian Paint Fungus, *Echinodontium tinctorium*. Conks of this pathogen could be seen at multiple levels in two grand fir trees, indicating severe stem decay. This decay greatly compromises stem strength at all levels of the stem where the fungus establishes. Infected overstory trees are a source of inoculum for infection of the understory grand fir. Infections establish early in the life of a tree and develop slowly throughout their life. Wounds that penetrate the cambium can greatly increase the rate of decay development by increasing the oxygen supply in the heartwood. This is a consideration for retention of young grand fir growing in the understory on this site. The hazards of both Indian paint fungus and root disease make grand fir an undesirable species on this developed site.

Several trees had moderately to severely weakened stem due to poor joints at double tops, in two cases, stems joined at or near the ground. In most cases of double tops or double stems in conifers, such joints are poorly supported and prone to failure. Three of the five grand fir trees with large double or dead tops were recommended for removal.

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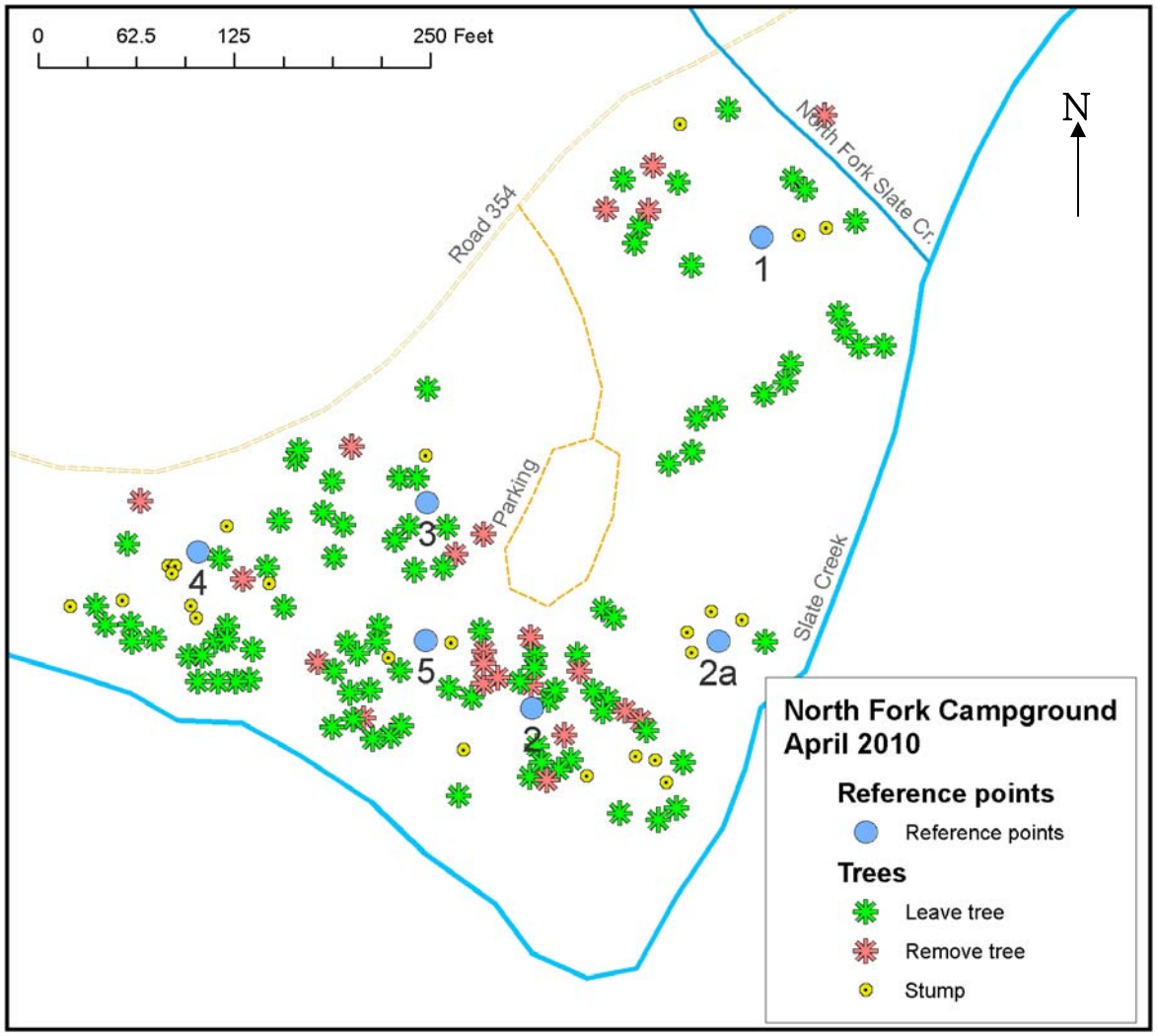

Figure 3. Composite map of trees and stumps in North Fork Campground. April 28, 2010

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Trees with a lean toward a target greatly increases the probability of a failure striking the target. Of 18 trees with significant root disease that were recommended for removal, five also had significant leans toward a target.

The largest number of removal recommendations surrounded unit 2. Here, nearly a third of the trees were tagged for removal, many were dead or dying. The average dbh of trees to be removed was 24 inches dbh and the remaining trees will average 16 inches dbh. This unit is on the active edge of a large root disease patch that is probably a single large pathogen clone. The perimeter of the disease patch is lined with dead trees, indicating the outward spread of the pathogen. The interior of the patch, which covers unit 1, has a large number of stumps from earlier tree removals; probably as a result of root disease mortality. Few live trees remain close to this campsite (unit 1) and these are very small and probably soon to succumb to the disease as well. The disease patch has extended into unit 2 in recent years, accounting for most of the removal recommendations in this unit.

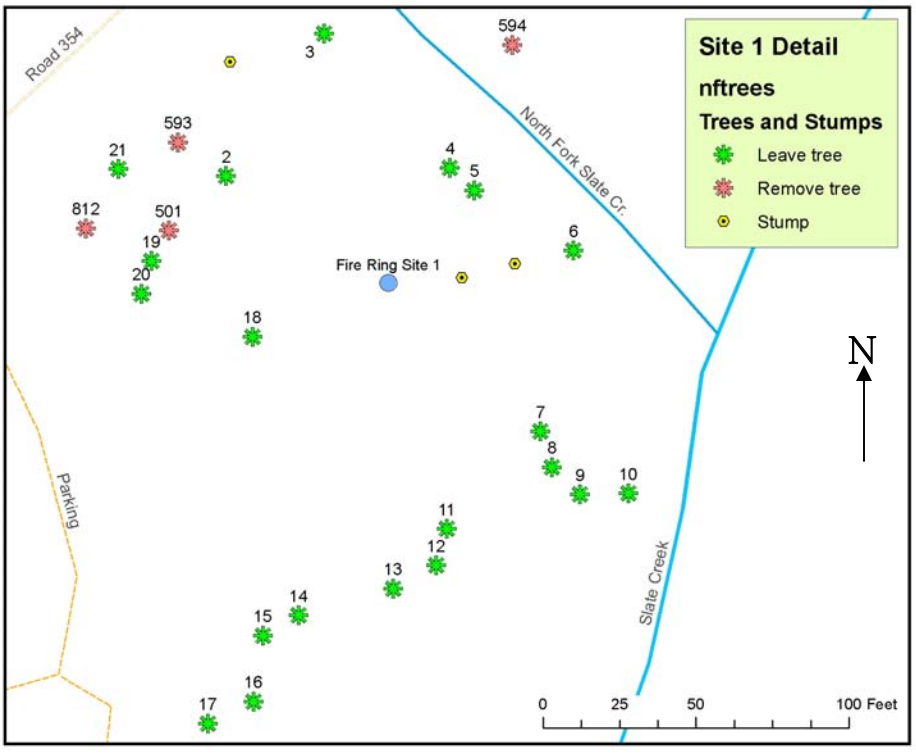
Table 6. Number of trees by recommended action

Unit	tentative removal	monitor	remove	no action	total
1			4	20	24
2		3	10	22	35
3		4	4	11	19
4		1	2	18	21
5	1		1	15	17
Total	**1**	**8**	**21**	**86**	**116**

Unit Summaries and Maps

Map 1; referenced from the fire ring in the northeast camp site which is bordered by the North Fork of Slate Creek and Slate Creek.

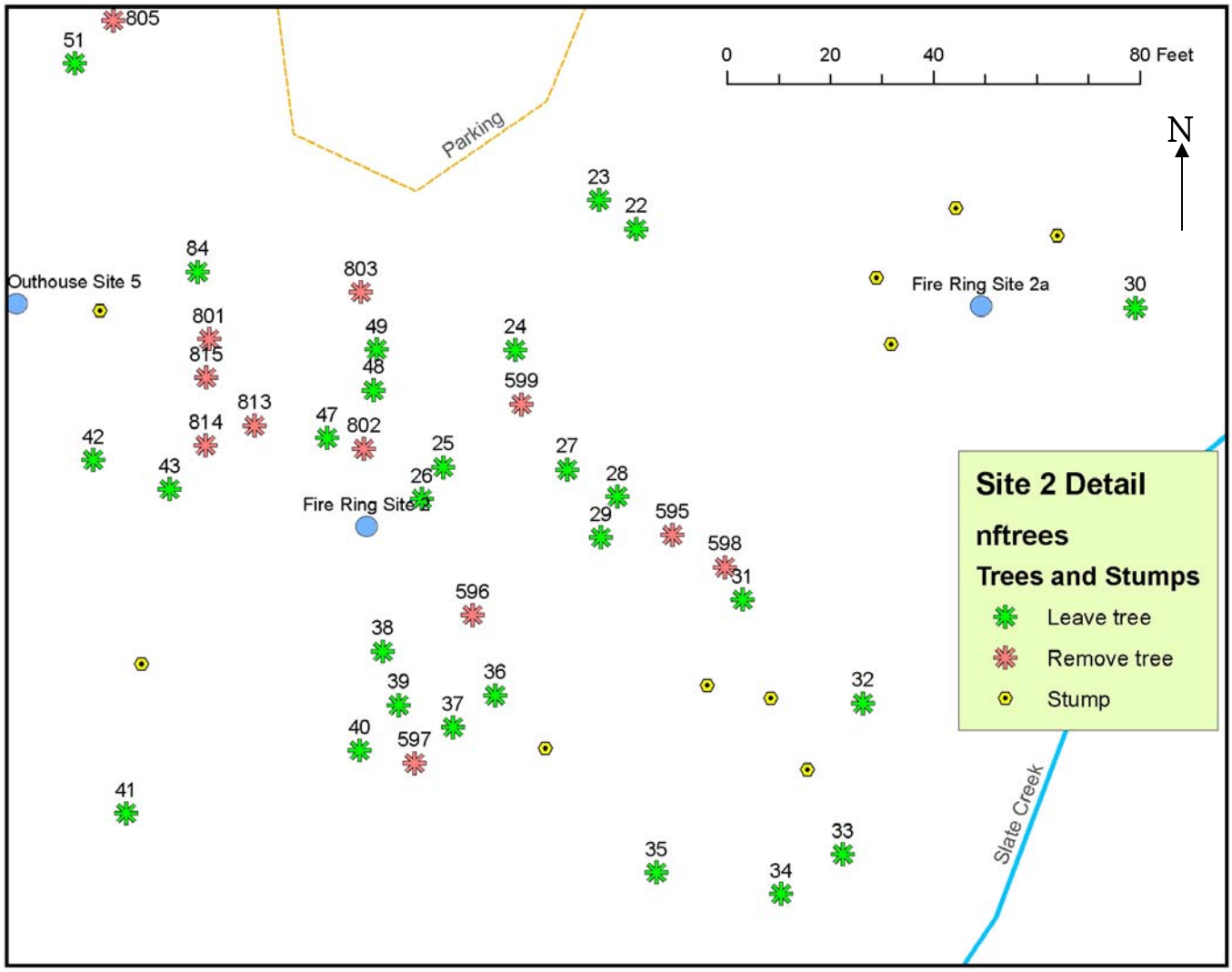
Of the 24 trees mapped in this unit, four were recommended for removal. Two of the trees to be removed are grand fir and two are Douglas-fir, all are large trees (average dbh = 31 inches) with advanced root disease. One of the Douglas-fir is already dead. What little canopy exists near the table and tent pad of this site is recommended for removal. The 20 trees remaining after hazard tree removal will be far enough away to provide little shelter. These trees will average 12.8 inches dbh. Tree planting is likely to be needed to restore aesthetics.



Map 2; Referenced from the fire ring in the east campsite on Slate Creek.

The 35 trees mapped in this unit included several dead trees and stumps from earlier removals. Ten trees were recommended for removal, one of these was a tall snag that is expected to fall in the short term. All but one have advanced root disease and most also have signs of significant butt rot. This site is on an active margin of the root disease patch that killed nearly all trees between unit 1 and unit 2. A high rate of mortality can be expected to continue in the remaining trees in unit 2. Replacement vegetation for this and unit 1 will be increasingly desirable as canopy is removed by disease.

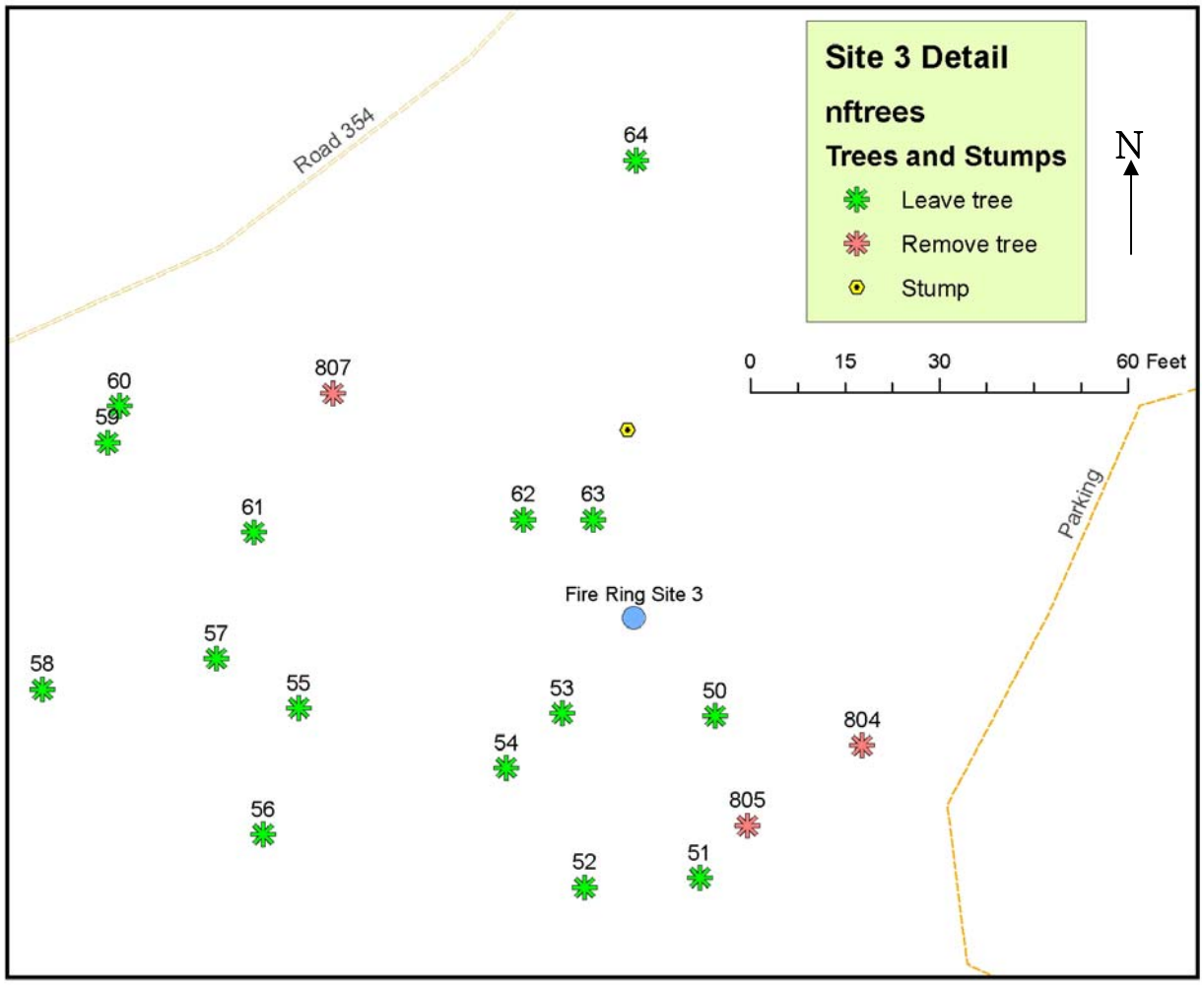
Three additional trees were identified for closer monitoring. One of these, tree #22 is a 30 inch dbh grand fir with root disease, butt rot and a significant lean. Two others to be monitored are also grand fir with root disease symptoms. Continued deterioration of the crown signifies increasing root decay.



Map 3; Referenced from the fire ring in unit 3 which is situated away from the creek between the road, the parking area for the trailhead and the outhouse.

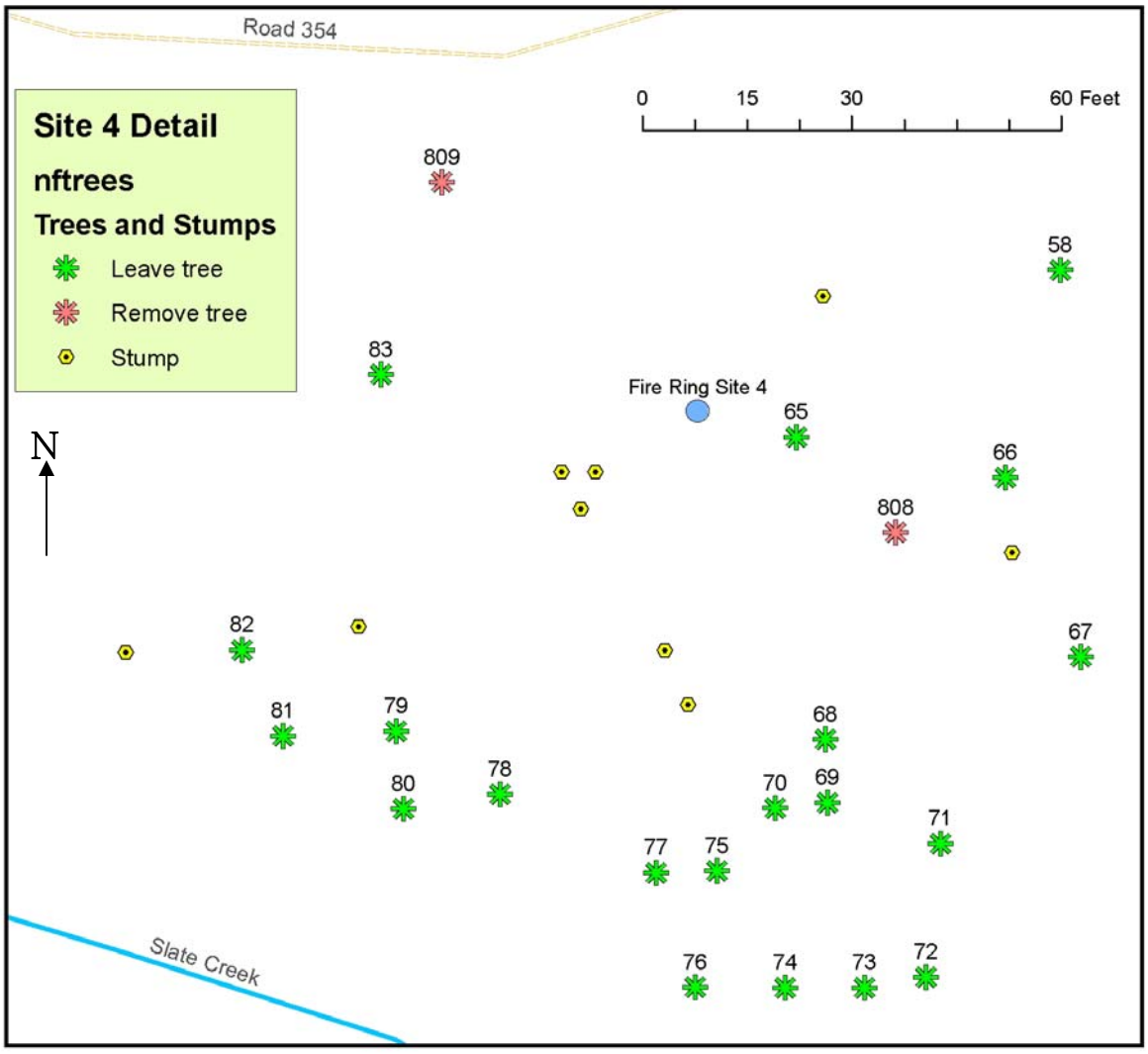
Four of the 19 trees mapped in this unit were tagged for removal. One of these is a dead Douglas-fir with root disease and the other three are large diameter grand fir with stem decay and root disease. One grand fir also has a dead top, probably caused by fir engraver beetle (*Scolytus ventralis*). These four trees average 31.1 inches dbh.

One Douglas-fir with root disease and a significant lean, and several large grand fir were identified for closer monitoring. These grand fir have root disease and associated butt rot. The Douglas-fir should be monitored closely for signs of root movement. In the grand fir, vertical butt cracks and basal cat-faces should be monitored for enlargement.



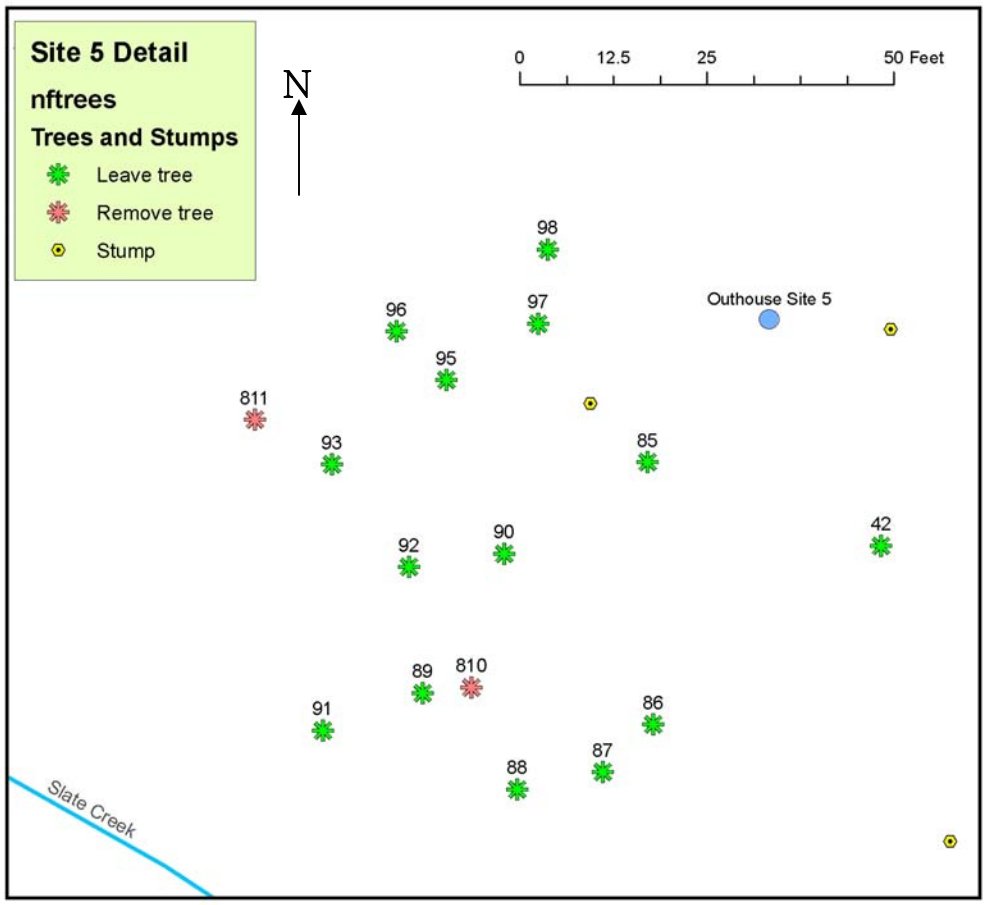
Map 4; Referenced from the fire ring in unit 4 west of the outhouse and bordered by the road and Slate Creek

Many of the symptomatic trees on this site lean strongly toward the creek and away from the developed site, so they were not considered to pose significant hazards. Therefore, only 2 of the 18 trees mapped on this unit were tagged for removal. Both of the trees identified for removal are grand fir with advanced root disease and butt rot. One is large, 31.4 inches dbh and leans toward the table. The other is fairly small, 14.3 inches dbh, and is scarred by chopping or axe-throwing. The tree recommended for annual monitoring is a large grand fir with a substantial lean but no obvious root disease. This tree should be watched for signs of root movement indicating progressive root failure.



Maps 5; referenced from southeast corner of the existing outhouse.

Of the 14 trees mapped in this unit, one was tagged for removal, and another for optional removal depending on the final site plan after moving the outhouse. Both of these trees are large grand fir with advanced root disease. Other trees with root disease have strong enough lean toward the creek to pose relatively little hazard to the developed site. No trees were identified as requiring specific monitoring in this unit.



Disease conditions and ecology of diseases on the site

Diagnosis

Root disease

Fir type Annosus root disease is seen throughout the campground as well as the surrounding stands. Butt rot and lesions with cat-facing are seen in most grand fir. Some lesions are distinct while others appear to be in the early stages of development. Crowns are generally thin with scattered dead branches. These symptoms are typical of slower decline symptoms of Annosus root disease.

Annosus root disease, caused by *Heterobasidion occidentale* (Otrocina & Garbelotto), has a fairly high rate of new clone establishment but can also form longer-lived, larger clones. North Fork campground is symptomatic of both types of clone development. Most of the trees have crown symptoms of annosus root disease and sporadic mortality is seen throughout the campground. There is one large disease patch that is probably caused by a single, very active clone.

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Root disease was the most common reason for recommending tree removals. Of 21 trees recommended for removal, 86% had significant root disease. Stem decay was often significant in these trees as well, especially as butt rot. This is a significant damage that is an extension of the root decay caused by *H. occidentale*. In grand fir and similar species (such as white fir, *Abies concolor*) the tap root is usually the first root to be completely decayed by *H. occidentale*. The fungus moves up in to the heartwood of the lower stem from the tap root.

Butt rot commonly extends 6-10 feet upward in the butt and, over time, will commonly leave only a thin shell of intact sapwood surrounding a hollow heart. Vertical cracking observed in the lower 10 feet of the stem is often the only indication of this condition. Cracks commonly develop callous along the edges, leaving an obvious ridge. Unstable cracks that move (generally in wind) often weep sap or other liquids. Bacteria and yeast may establish in the heartwood decay and increase production of liquid, often with an unpleasant odor. The greatest significance of these symptoms in developed sites is the increased likelihood of tree failure near the ground level because of the decay and unstable cracks.

Indian paint fungus

Two large, old grand fir have extensive heartrot caused by Indian paint fungus. Several fruiting bodies were observed on both trees, each one indicating heartrot extending an average of 8 feet of length in both directions.

Prognosis for large trees and regeneration

This late-seral stand can be expected to lose the few remaining mature Douglas-fir to root disease. Mortality of the mature grand fir trees is expected to continue at a rate of a few trees per year even after removal of the recommended trees. Nearly all succumb to the disease eventually.

Fir engraver beetle activity is difficult to predict but a likely consequence of root disease weakening trees. Increasing decay in roots and butts will also cause grand fir to be more likely to fall. Additional heartrot caused by Indian paint fungus may be observed. It is hard to say whether the trees recommended for removal were the only ones affected by this disease.

The trees should be monitored yearly for changes in condition, particularly those identified as having developing conditions. Removals may be warranted, occasionally, when trees have died, or when imminent failure places people and property at risk. Root disease crown symptoms should be taken very seriously in a developed site because they indicate significantly compromised root systems. Trees often have high rates of root decay before they develop detectable crown symptoms of the disease.

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Recommended actions

- **Remove trees that pose unacceptable hazards or remove the target to reduce the potential for personal or resource injury.**
- **The diseases and insects that afflict the firs here are natural and predictable, as is their course of development. Root disease resistant species such as pines and western larch have the potential to create fewer management challenges over the long term. Where practical, these species should be regenerated for future canopy.**
- **Examine each tree identified as requiring monitoring and maintain an annual record of the exam. This background will be invaluable in anticipating tree failure.**
- **Be prepared to remove additional trees that show unacceptable increases in risk**
- **Prepare and apply a comprehensive vegetation management plan that addresses long term tree health.**

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Generally the greater the available soil moisture, the more decay a tree will tolerate before developing crown decline. Such trees can be particularly dangerous in a developed site because the true condition of the roots is not easily assessed.

Most of the young trees on the site are grand fir and Douglas-fir. Trees of these species can be expected to become infected by root pathogens and eventually exhibit symptoms similar to those seen in the current stand. There is no practical means to prevent their infection and subsequent development of disease.

Establishing a more disease-resistant stand can decrease maintenance costs and improve visitor safety while protecting the aesthetics of the site. We highly recommend developing a plan for maintaining and improving the vegetation on this site.

Fir-Annosus (Heterobasidion occidentale) root disease ecology

Grand fir, Douglas-fir, and subalpine fir are the most damaged hosts of fir-annosum in Idaho. True firs and Douglas-fir are most likely to be killed by fir-annosus root disease, while growth loss and slow decline is typical of annosus-afflicted western redcedar. Pines and western larch can become infected but lesions are typically limited and damage is rarely significant in these species.

In contrast to *Armillaria* root disease, minimal root-to-root spread is seen in most fir-annosus root disease clones. Instead, spore infections of roots and lower stem wounds appears to be the main mechanism used for infection of trees. Spores are produced in abundance throughout most of the year to allow the fungus to take advantage of any fresh wounds. Spores are washed into soil pores by rain and penetrate directly through thin root bark. Root feeding insects and rodents also may be a significant source of root wounds that allow fungus infection. Though the mechanisms are poorly understood, it is clear that high rates of infection are typical of mature grand fir, subalpine fir, and western redcedar in northern Idaho. Despite high infection rates, mortality rates usually are usually low except where *Armillaria ostoyae* is present as well.

The tap root of grand fir is typically rotted off by this fungus in the first few decades. The fungus spreads from the killed taproot into the butt heartwood where it can cause considerable butt decay by the time the tree reaches maturity. Butt rot of this type is especially common in grand fir and western redcedar. Butt rot and associated root decay produce significant risk of tree failure while the tree is alive and such damage can be hard to detect, especially in grand fir.

When trees with root, and especially butt infections die, the pathogen produces shelving conks which produce tens of thousands of spores for several years after the death of the host. Many naturally-occurring saprophytic fungi invade conifer stumps and roots shortly after tree death and can provide some stiff competition for *H. occidentale*. These organisms have the potential to limit the development of root disease fungi and are probably the most important natural controls for fir-annosus as well as other root diseases as they compete for woody substrates. To the extent that these saprophytes usurp substrates from the pathogen, they can reduce the production of spores by *H. occidentale*.

Indian paint fungus ecology

Infected overstory grand fir with stagnated understory grand fir provides the ideal situation for development of Indian paint fungus (*Echinodontium tinctorium)* infection. Spores produced in the infected overstory drift down to the understory grand fir. Indian paint fungus initially establishes infections in shade-killed branches. The fungus produces a quiescent infection in which it fails to progress much beyond the original point of establishment for some years. As the tree grows, the dead, infected branch stub is incorporated in the heartwood. Once surrounded by the no-longer-living heartwood, which is thereby no longer resistant, the fungus begins to grow. It lives entirely by decaying dead heartwood, never invading live sapwood.

Decay caused by *E. tinctorium* can be especially extensive. A single young *E. tinctorium* conk may indicate a decay column extending 8 feet above and 8 feet below the conk. Larger, older conks may indicate 20 feet below and 21 feet above the conk. Two or more conks, widely separated on the stem, probably indicate that virtually the full length of the stem has a central column of decay. The longer the column is, the greater the width of the decay column.

Wounds that kill a patch of cambium are known to greatly accelerate the extent and perhaps the rate of decay caused by Indian paint fungus. A wedge of dead wood often will extend behind the wound to merge with the heartwood, thereby increasing aeration of the heartwood and improving growing conditions for the fungus.

Wounds are a highly significant factor in predicting decay volumes in grand fir. Root disease or beetle caused mortality which leads to trees falling, wind breakage and animal or human-caused stem damage all result in stem wounds that contribute to stem decay acceleration.

Recommendations for Monitoring of Hazard Trees

Annosus root disease

Crown symptoms indicating root disease progression may be evident after sufficient lateral root decay has occurred. Crown deterioration may be slow to develop in annosus-afflicted grand fir. Their root systems may have 60-80% or more root destruction with little or no crown symptoms. If symptoms are seen, however, they should be taken to indicate an extremely compromised root system. Even after the tree has ceased to move water or nutrients up from the roots, it can take a year or more for the crown to die.

Crown symptoms of root disease usually show for several years before a tree dies. The amount of root system decay can be expected to be at

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Figure 4. Root disease crown symptoms are often more dramatic in Douglas-fir (left photo) than in grand fir (right photo). In both pairs of trees, the tree on the right has the most severe disease.

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least as much, proportionally, as the loss of foliage in the crown. Therefore, a tree that has lost about 80% of it's foliage and can be expected to have at least 80% root mortality. However, a dead root will provide physical support until it is weakened by decay. The degree to which a root is decayed is a function of how long the root has been dead. The slower the disease develops the higher the proportion of decay in killed roots.

It follows that trees that have been recognized as declining for many years can be expected to have more severe root decay, and less support, than trees that have died quickly.

Both root and stem decay are important factors in producing tree hazards. Taproot decay is usually the first damage to occur in a grand fir and does not cause crown symptoms. Butt rot develops from the decayed taproot and likewise does not cause crown symptoms but advanced butt rot can result in stem cracking. Decay in the butt heartwood causes instability in the lower stem and probably results in differential freezing and thawing, either condition may cause vertical cracks to form (Figure 5). Water is a decay process byproduct. The stem decay produces excess water that will often exude from these vertical cracks.

Figure 5. Butt cracks can extend many feet up from the ground. They may covered with be wide seams of callous tissue, have ridges of callous along the edges of the crack, or show little evidence of callous formation, depending on how recent the crack formed and how much movement there has been.

Cracks should be monitored for increases in width and length as well as increased flow of water which often is discolored and foul smelling.

Root movement (Figure 6) is also a strong indicator that tree failure is imminent. Generally some increase in leaning can be observed as well but if a tree is already leaning, root movement may be the more obvious symptom. Exposed roots may also indicate root damage caused by foot or other traffic (including wildlife trails).

Figure 6. Root movement is indicated by roots that are exposed near the root crown. These roots may be progressively lifting as decay destroys the structural strength of the unseen portions of the root.

To monitor for root movement, watch for ground heaving or lifting within two or three feet of the butt. Trees with root movement are often very unstable.

Tracking Monitoring Reports

Monitoring follow-through is a critical part of hazard tree management. Each tree has a unique set of circumstances. Each identified tree should be checked annually with a permanent record of each exam maintained where it is accessible. Trees that were identified as possible bark beetle attacks may be removed from further monitoring if no additional symptoms are seen after one year.

Table 7 presents details on each of the trees we recommended for monitoring. An excel spreadsheet is a convenient form to track monitoring results from year to year (Appendix C). These data provide a permanent record of monitoring results. Significant changes in tree condition can be assess based on previous records. Photographs of significant conditions can be useful for comparison.

Factors which continue to be important for tree risk evaluation are:

- The importance (and permanence) of the target,
- The species of tree and attending susceptibility of that species to damage agents and wind breakage,
- And the combination of diseases, insects and physical conditions found in the assessment.

Table 7. North Fork Campground trees to be monitored.

Tree # (azimuth/ distance*)	Reference point	Sp.	dbh	Target	Defect description (Damage codes)	Monitor for:
22 (30° / 50')	Unit 2 fire ring	GF	30.0	Unit 2	Root disease thin crown, Butt rot with crack, 15-20° lean (3R,2D,3L)	More severe crown symptoms, death, butt crack movement, root movement, increase lean.
25 (60° / 15')	Unit 2 fire ring	GF	24.6	Unit 2	Root disease thin crown (3R)	More severe crown symptoms, death
26 (70° / 10')	Unit 2 fire ring	GF	17.9	Unit 2	Root disease slightly thin crown. (2R)	More severe crown symptoms
50 (135° / 25')	Unit 3 fire ring	DF	22.5	Unit 3	Slightly thin crown, butt rot, 15-20° lean. (2R, 2D, 3L)	Root movement, increase lean, root movement.
56 (240° / 60')	Unit 3 fire ring	GF	47.2	Unit 3	Butt rot with vertical crack. (2D)	Crack enlargement, weeping.
59 (290° / 60')	Unit 3 fire ring	GF	40.3	Unit 3	Large vertical crack, 10-15° lean (2W,2D, 2L)	Crack enlargement, increase lean, root movement.
60 (295° / 60')	Unit 3 fire ring	GF	18.4	Unit 3	Root disease thin crown, 10-15° lean (3R, 3L)	More severe crown symptoms, death, root movement, increase lean
65 (110° / 10')	Unit 4 fire ring	GF	25.9	Unit 4	15-20° lean (3L)	Root movement or increased lean.

* Measured or approximated from mapped tree position and measured points.
** See Appendix A for damage codes.

Citations and Other Resources

Hazard tree evaluation and management:

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Vegetation Management Planning
Vegetation Management Planning Template, Northern and Rocky Mountain Regions, Recreation and Lands, USDA Forest Service, 2010.